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PATENT
Attorney Docket No. 2888.2 (91-578.2)

CERTIFICATION UNDER 37 C.F.R. § 1.10 (if applicable)

Express Mail Mailing Label No.: EM328717196US Date of Deposit: February 13, 1997

I hereby certify that this 37 C.F.R. § 1.60 request and the documents referred to as attached therein are being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 C.F.R. § 1.10 on the date indicated above and are addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231.

Typed or printed name
of person mailing application: Timothy Ricks

Signature of person mailing application

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Anticipated Classification of this application: Class: 375 Subclass: 358

Prior application: Modulated Spread Spectrum in RF Identification Systems Method Examiner: Don N. Vo Art Unit: 2614

Prior application serial no.: 08/348,274

TRANSMITTAL OF FILING UNDER 37 C.F.R. § 1.60(b)

Box Patent Application
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

This is a request for filing a ☐ continuation, ☒ divisional application under 37 C.F.R. § 1.60 of pending prior application serial no. 08/348,274 filed on November 30, 1994 of John R. Tuttle, James C. Springett, and Eugene P. Hoyt for MODULATED SPREAD SPECTRUM IN RF IDENTIFICATION SYSTEMS METHOD.

1. ☒ Enclosed is a copy of the latest inventor-signed prior application as filed, including a copy of the oath or declaration showing the original signature or an indication it was signed. I hereby verify that the attached papers are a true copy of the latest SIGNED prior application serial no. 08/348,274. (NOTE: The latest signed application is not necessarily the immediately preceding parent application.)

2. ☐ A verified statement to establish small entity status under 37 C.F.R. §§ 1.9 and 1.27

   ☐ is enclosed.
   ☐ was filed in prior application serial no. and such status is still proper and desired (37 C.F.R. § 1.28(a)).

3. ☒ The filing fee is calculated below:

CLAIMS AS FILED IN THE PRIOR APPLICATION, LESS ANY CLAIMS CANCELLED BY AMENDMENT BELOW

Number filed	Number extra	Basic Fee $770.00
Total claims 5 - 20 = 0 x 22.00 =		-0-
Indep. claims 2 - 3 = 0 x 80.00 =		-0-
Multiple dependent claim(s), if any x $260.00		
Reduce by 1/2 for small entity status if applicable		-
TOTAL		$770.00

4. ☒ Check No. 8032 in the amount of $770.00 is enclosed.

5. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required but not submitted with any document or request requiring fee payment under 37 C.F.R. §§ 1.16 and 1.17 to deposit account no. 20-1469 during the entire pendency of this application. A duplicate copy of this sheet is enclosed.

6. ☒ Cancel in this application original claims 2-28 of the prior application before calculating the filing fee. (At least one original independent claim must be retained.)

PATENT
Attorney Docket No. 2888.2 (91-578.2)

7. ☐ Amend the specification by inserting before the first line the sentence:
This is a ☐continuation, ☐division of application serial no. 08/348,274, filed November 30, 1994, pending.

8. ☒ Copies of the original drawings as filed are enclosed. (NOTE: True copies of drawings as filed in the latest inventor-signed application must always be enclosed IN ADDITION to any new formal drawings.)

9. ☐ New formal drawings are also enclosed.

10. ☐ Priority of application serial no. filed on in is claimed under 35 U.S.C. § 119.
☐ The certified copy has been filed in prior application serial no. , filed on .

11. ☒ The prior application is assigned of record to Micron Technology, Inc.

12. ☒ The Power of Attorney in the prior application is to (cross out any that do not apply) David V. Trask, Reg. No. 22,012; William S. Britt, Reg. No. 20,969; Thomas J. Rossa, Reg. No. 26,799; Laurence B. Bond, Reg. No. 30,549; Joseph A. Walkowski, Reg. No. 28,765; James R. Duzan, Reg. No. 28,393; Allen C. Turner, Reg. No. 33,041; Julie K. Morriss, Reg. No. 33,263; Robert G. Winkle, Reg. No. 37,474; Patrick McBride, Reg. No. 39,295; Edgar R. Cataxinos, Reg. No. 39,931; Michael L. Lynch, Reg. No. 30,871; Lia M. Pappas, Reg. No. 34,095

a. ☐ The power appears in the original papers in the prior application serial no. .

b. ☒ Since the power does not appear in the original papers, a copy of the power in the prior application is enclosed.

c. ☐ A new power has been executed and is attached.

13. ☒ A preliminary amendment is enclosed.

14. ☐ The inventor(s) of the invention being claimed in this application is (are): John R. Tuttle, James C. Springett, Eugene P. Hoyt.

15. ☐ This application is being filed by less than all the inventors named in the prior application. In accordance with 37 C.F.R. § 160(b), delete the name(s) of as inventor(s), such person(s) not being inventor(s) of subject matter claimed in this application.

16. ☐ A petition, fee and response has been filed in the pending prior application to extend the term for response therein to and including . A copy of the petition for extension of time in the prior application is enclosed.

17. ☒ Direct all future communications to Joseph A. Walkowski at the telephone number and address indicated below.

18. ☐ Also enclosed:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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Date: February 13, 1997
Enclosures: As identified above plus postcard

PAT. & TRADEMARK OFF.

MICRON NO. 71-578/72-06

Be It Known That We, **John R. Tuttle**, a citizen of the United States of America, resident of Boise, County of Ada, State of Idaho, **James C. Springett**, a citizen of the United States of America, resident of La Canada, State of California, and **Eugene P. Hoyt**, a citizen of the United States of America, resident of Colorado Springs, State of Colorado, have invented a new and useful

Modulated Spread Spectrum in RF Identification Systems Method

of which the following is a specification:

MAIL ROOM

Specification

Field of the Invention

This invention relates to data communication with low power radio frequency (RF) transceivers, specifically to data communication between RF identification (RFID) tags and an operator (interrogator), and more particularly, to using spread spectrum techniques to simplify the tag receiver design, reduce tag cost, increase the range and reduce interference on the RF communication channel.

Background of the Invention

An RFID tag is a small radio transceiver that can be attached to a movable article to help keep track of its whereabouts and status. A small, light-weight inexpensive tag is desirable. To miniaturize the tag, the size of the circuitry is reduced by using an integrated circuit (IC) design. The simpler the circuit, the smaller the resulting IC becomes thereby reducing the cost.

Operational environment factors can disrupt the reliability of these weak communication links. Reflective and refractive properties of the environment introduce possible multipath errors, and outside RF sources introduce interference in the received signal.

Summary of the Invention

The principle object of this invention is to provide a method by which an RFID tag can communicate more information over

much greater distances through harsher RF environments than previously available, while reducing the size and cost of the tag IC.

The secondary objects of this invention are to provide simple AM reception by the receiver circuit without having to use complex synchronization schemes, external frequency references such as quartz crystals and complex circuits like Costas loops;

interrogator transmission power to be less than or equal to 1 Watt, allowing unlicensed operation within FCC guidelines;

extension of the range from interrogator to RFID tag;

limitation of eavesdropping of signals by outside parties, and;

selective addressing of particular tags or communicating with more than one tag simultaneously in any given transmission.

These and other objects are achieved by modulating a spectrally spread carrier with a pulse code waveform representing information pertaining to the article to which the tag is attached.

One advantage of using a spread spectrum modulated signal is the enhanced interference rejection obtained during the demodulation process. The effect is a signal to noise gain over traditional narrow band broadcasting techniques.

Using spread spectrum techniques gives good range with relatively little complexity on the tag. The high complexity is contained in the interrogator design.

Other advantages are: selectively addressing a particular receiver, pulse code multiplexing allowing addressing of a

plurality of receivers in any given transmission, broadcast transmissions with low density power spectra for signal hiding, message encryption to discourage eavesdroppers, and high resolution ranging between transmitter and receiver.

Although this invention was specifically designed for RFID tag communication, there are applications for it in hand-held walkie-talkies, pagers, mobile phones, cordless telephones, cordless microphones and musical instruments, cordless computer network communication links, and intercoms.

Brief Description of the Drawing

Figure 1 is a simplified drawing of the type of radio frequency identification system to which this invention applies.

Figure 2 is a block diagram of the transmitter part of the interrogator.

Figure 3 is a series of time domain plots representing binary phase shift keying (BPSK) the carrier with a direct sequence pseudo-random pulse code.

Figure 4 is a frequency domain plot of an ideally spectrally spread carrier.

Figures 5A-5B are a realistic time domain plot and frequency domain plot of the BPSK spectrally spread carrier.

Figure 6 is a series of time domain plots representing pulse amplitude modulating the spectrally spread carrier with a pulse code waveform.

Figures 7A-7B are a realistic time domain plot and frequency

domain plot of a pulse amplitude modulated non-spectrally spread carrier.

Figures 8A-8B are a realistic time domain plot and frequency domain plot of a pulse amplitude modulated spectrally spread carrier.

Figure 9 is a block diagram of the transceiver in the REMOTE RFID tag.

Figure 10 is a time domain plot representing one data bit period of the received signal 1+PN1(t)d(t) after the carrier has been removed.

Figure 11 is a time domain plot representing one data bit period of the received signal without carrier that has been gated by PN1(t) in sync.

Figure 12 is a time domain plot representing one data bit period of the received signal without carrier that has been gated by PN1(t) that is 3 chips out of sync.

Figure 13 is a time domain plot representing one data bit period of the received signal without carrier that has been gated by the logical compliment of PN1(t) in sync when d(t)= 1.

Figure 14 is a time domain plot representing one data bit period of the received signal without carrier that has been gated by PN1(t) in sync when d(t)= 1.

Figure 15 is a time domain plot representing one data bit period of the received signal without carrier that has been gated by the logical compliment of PN1(t) in sync when d(t)= -1.

Figure 16 is a time domain plot representing one data bit period of the received signal without carrier that has been gated

by PN1(t) in sync when d(t)= -1.

Description of the Prefered Embodiment of the Invention

Referring now to FIG 1, a typical arrangement of an RFID system includes a plurality of operator controlled interrogators **A** that communicate via RF links with a plurality of RFID tags **B** which are attached to articles **C** located somewhere in the vicinity of the interrogators.

An interrogator transmits a signal to a particular tag requesting or updating the status of the article associated with that tag. Status information can include the article's name, owner, address, destination, pertinent dates, weight, etc.

The tag receives the signal and awakens from its power conserving quiescent sleep state. The tag interprets the request and decides on a response which is then transmitted back to the requesting interrogator. A receiver in the interrogator analyzes the return signal, determining the status of the article. Its location can be determined by triangulation with multiple interrogators or multiple antennas. This information is then displayed to the operator.

Referring now to FIG 2, a block diagram of the transmitter part of the interrogator transceiver, a crystal controlled oscillator **1** generates a constant amplitude sinusoidal carrier with a frequency of 2441.75 MHz.

This carrier is modulated in the balanced modulator **2** by a pseudo-random direct sequence pulse code, PN2, generated by the

pseudo-noise (PN) generator 3. PN2 has a chip rate of about 40 Mega-chips per second.

The resulting spectrally spread carrier is then modulated 4 by another pulse code waveform generated by combining a data waveform 5 and another pseudo-noise waveform, PN1(t) 6. The resulting signal to be transmitted is sent to a power amplifier 7, and then to the antenna 8.

The data waveform, d(t) represents information to be transmitted to the REMOTE and has a data rate of about 2 mega-bits per second. PN1(t) has a chip rate equal to or less than PN2. In this embodiment PN1(t) and d(t) are multiplied together to form the modulating unipolar waveform, 1+PN1(t)d(t).

The waveforms of FIG 3 refer in detail to operation of the first balanced modulation of the carrier. Modulation occurs by binary phase shift keying (BPSK) the original constant amplitude carrier 9, with the PN2 pseudo-random direct sequence pulse code 10. During the time when PN2 is low, the carrier is keyed with a 180 degree phase shift from when PN2 is high 11. For illustration purposes, the sinusoidal carrier is shown at a much lower frequency then has been suggested for this embodiment.

The resulting waveform has a power spectrum which is ideally spread according to the (sin(x)/x)**2 function shown in FIG 4. The center of the main lobe is at the original carrier frequency Fc. The mainlobe bandwidth (null to null) is now twice the clock frequency of the PN2 waveform Fg. A more realistic representation of the time domain signal and its power spectra

appears in FIG 5a and FIG 5b respectively.

FIG 6 illustrates in detail the operation of the modulation of the spectrally spread carrier by the pulse code waveform 1+PN1(t)d(t). The spectrally spread carrier **11** of FIG3 is viewed over a much greater time period **12**. One must keep in mind that there are over 150 cycles of the original carrier for every bit (amount of time between possible changes, high-to-low or low-to-high) of the 1+PN1(t)d(t) modulating waveform **13**.

Pulse amplitude modulation involves multiplying the spread spectrum carrier by the modulating waveform **14**. It is important to note that pulse amplitude modulating a non-spectrally spread carrier results in a power spectrum with an undesirable spike **15** at the carrier frequency as shown in FIG 7a and FIG 7b. By spectrally spreading the carrier, the resultant power spectra is more acceptable as shown in FIG 8a and FIG 8b.

Referring now to FIG 9, the receiver portion of the remote RFID tag receives signals via an antenna **16**. In order to sense the existance of a signal meaningful to the REMOTE, the signals are sent to a lowpass filter **17**. This voltage is compared to a value Vo in a comparator **18**. If the voltage is greater, the comparator outputs a true, informing the sequential mode logic **19** that a signal is present. The receiver is then initialized, awakening from its quiescent sleep state and the PN1(t) waveform generation circuitry is set to acquisition mode through the PN epoch controller **20**.

In an awakened REMOTE, the signal arriving at the antenna **16**

is sent to several stages of RF (S-band) amplification and filtering **21**. As much RF amplification as attainable is provided. The bandpass filter characteristics are a center frequency of the original carrier (2441.75 MHz) and a bandwidth of around 84 MHz, which corresponds to the main lobe of the transmitted signal. Although this bandpass filtering is shown as a single block **22**, the circuitry accomplishing this filtering will likely be distributed throughout the RF amplifier circuits.

The resulting signal is sent to a full wave envelope demodulator **23**, which recovers the amplitude modulating waveform as 1+PN1(t)d(t). Some added lowpass filtering **24** and baseband amplification **25** further increases the voltage level of the waveform to a more useful value (approx. 0.5 Volts peak-to-peak).

As seen in FIG 10 the waveform 1+PN1(t)d(t) is essentially two-level in nature, exhibiting positive and negative transitions between the limits of 0 and Vs which correspond to the PN1(t) waveform, and a small amount of additive noise or interference. Here, PN1(t) is represented by the chip sequence: 1 1 1 -1 -1 1 -1 -1, and spans exactly one data bit period, Td. It can be assumed during this time period that d(t)=1; if it were a -1, the waveform would be inverted. In order to facilitate synchronization, d(t) is equal to 1 and thus non-transitioning during a preamble portion of the transmitted signal.

Referring back to FIG 9, the transition pulse generator **26** acts to differentiate the 1+PN1(t)d(t) waveform, producing "spikes" at the transition times, which are then rectified (absolute value) to furnish a unipolar train of transition

derived pulses. Spectrally, this waveform is rich in the PN1(t) code clock frequency. It's injected into a free-running multivibrator **27** (or a phase-locked loop oscillator) which produces a synchronized pulse for every chip of the received signal. In effect the waveform produced is a relatively stable PN1 clock waveform used by the PN1 generator **28**. Once synchronization to the incoming PN1 sequence is achieved, the locked multivibrator **27** is used as the tag's clock for processing the incoming data and commands. If a return transmission is requested, the locked multivibrator **27** becomes the source for the tag transmitter carrier frequency.

The PN1 generator **28**, running from the PN-clock waveform, generates the tag's version of the PN1(t) chip sequence. This will initially be time offset by an integral number of chips (n) from the sequence that makes up the received waveform 1+PN1(t)d(t). The PN Sync Detector **29** eleminates this offset.

The PN Sync Detector accomplishes its objective by doing a sequential correlation comparison. A MOSFET switch **30** gates the 1+PN1(t)d(t) code received using the PN1 code generated. If the two codes are in sync, the output of the gate is a waveform FIG 11, having an average value around Vs/2. If the two codes are unaligned, say offset by three chips, the gate output is a waveform FIG 12, having an average value around Vs/4 or less. By usual spread spectrum standards, correlation discrimination by a factor of two would be considered poor, but under very high signal to noise ratio (SNR) conditions, which are present in the forward link, it is acceptable.

The proper, in-sync starting point for the PN1 code sequence is discovered by generating PN1 at all possible starting points and recording the results. Each starting point represents a waveform which is a possible candidate for being the correct in-sync PN1 waveform. The candidate having the largest correlation value will be the one used. A more detailed explanation of this process follows.

Upon initialization, the Sequential Mode Logic **19**, in conjunction with the timing events T1 and T2 **31**, initializes the sample-and-hold (S&H) memories **32** and **33**. T2 occurs later than T1. The event of T1 causes the output of LPF4 **34** to be stored in S&H #1 as value E1. Likewise, T2 results in E1 being stored in S&H #2 as value E2. LPF4 is responsible for smoothing the correlation voltage producing a more accurate representation of the correlation than what is available from the broader LPF2 **35** which is matched to the bit period. Initially, the sequential mode logic sets the PN epoch controller **20** to produce a shift-register word which is loaded into the PN generator's shift-register directing the generator to produce the PN1 code sequence at a particular staring point called epoch-1. If the code sequence is made up of L chips, there are L possible starting points and L possible epochs. (In the example waveform in Figure **4**, L = 8). The PN sync detector must find epoch-n corresponding to the largest correlation, with $1 <= n <= L$. Once the generator is producing PN1 based on epoch-1, the correlation value output from LPF4 is transferred to S&H #1 at T1

and then to S&H #2 at T2.

Next, the chip sequence based on epoch-2 is generated. The output from from LPF4 is again sent to S&H #1 at T1. If E1 is greater than E2, the correlation at epoch-2 is greater than the correlation at epoch-1. This is communicated by the output of the comparator **36** to the sequential mode logic which transfers E1 to S&H #2 and makes note of the epoch value n (in this case 2) for which the tranfers occurred. If E1 had been less than E2, Then E2 remains unchanged. The acquisition search continues with epoch-3 and so on until all epoch values have been tried. In the end E2 will represent the largest correlation value found, and the sequential mode logic will know which epoch value to use.

There is the possibility that proper alignment was not achieved because a correlation value mistake was made due to noise. To avoid this, the entire aquisition process is repeated two more times. PN synchronization success is declared if the epoch chosen is the same for all three tries (or two out of three tries).

Once PN1 has been synchronized with the received signal, the REMOTE is ready to detect data. Remember, throughout the acquisition period the LOCAL interrogator has been transmitting with d(t) equal to 1. This period will last for several hundred data bit periods. The start of a message packet will be indicated by a data transition from 1 to -1, followed by a block of unique bits which the data management logic will recognize as packet synchronization.

Data detection itself takes place as the received signal 1+d(t)PN1(t) is gated **30** by the tag's generated PN1 and sent to LPF2 **35**. Likewise, it is gated by PN1's logical compliment **37** and sent to LPF1 **38**. When d(t) is equal to 1, the input to LPF1 is the waveform seen in FIG 13, and the corresponding input to LPF2 is seen as FIG 14. The average value of the waveform sent to LPF2 is clearly greater. When d(t) is equal to -1, the inputs to LPF1 and LPF2 are as shown in FIG 15 and FIG 16 respectively. Here, the average value of the waveform sent to LPF1 is greater.

The two low pass filters, LPF1 and LPF2 are approximations to matched filters (if a simple RC filter is used, then RC = 1.3/(2pi*Td)). They function to maximize the SNR at the end of the bit period, Td, for input to the comparator **39**. End of bit period timing is provided by a state AND gate **40** operating from the PN1 generator. This gate toggles a J-K flip-flop **41** which temporarily stores the value of d(t) until it can be transferred into data management logic **42** and RAM **43**.

Each sequential data bit provides its own detection reference to the comparator. Also, as the received signal level varies due to movement of the tag or interrogators or changes in the RF environment, the data detection decision reference is self-adjusting, giving rise to the designation "per-bit" reference for data detection.

Once the forward link data has been detected, the data management logic **42** (executes required actions) and assembles the return link data packet message.

The transmitter within the tag will generate the return link

carrier by multiplying the PN1 clock frequency produced by the locked multivibrator **27** by a factor M using a frequency multiplying circuit **44.** This carrier is then amplified **45** and pulse amplitude modulated **46** by the return data packet waveform. Although an amplitude modulation scheme is shown, other modulation schemes using spread spectrum techniques are possible and desirable. This signal is then sent to the antenna **47.** The power amplifier stage may be less than .5 milliwatts due to the power available within the tag. Because of this low radiated power, spectrally spreading the return link carrier may not be necessary, and an additional pseudo-noise waveform analogous to PN1 need not further encrypt d(t). When higher powers are desired, a spectrally spread scheme would be used to satisfy FCC unlicensed rules. To extend the range of the system, spread spectrum techniques are desirable in the tag transmitter.

While the preferred embodiments of the invention have been described, modifications can be made and other embodiments may be devised without departing from the spirit of the invention and the scope of the appended claims.

WHAT IS CLAIMED IS:

1. A method for communicating pulse coded information between low power transceivers which comprises:

spectrally spreading a carrier; and

modulating the spectrally spread carrier with a data pulse code waveform comprising information to be transmitted, to form a modulated spectrally spread (MSS) signal.

2. The method of Claim 1 wherein said spectrally spreading a carrier comprises phase shift keying (PSK) the carrier with a first direct sequence pseudo-random pulse code waveform.

3. The method of Claim 2 wherein said phase shift keying comprises binary phase shift keying (BPSK).

4. The method of Claim 1 wherein said spectrally spreading a carrier comprises generating a frequency hopping signal.

5. The method of Claim 1 wherein said spectrally spreading a carrier comprises generating a time hopping signal.

6. The method of Claim 1 wherein said spectrally spreading a carrier comprises generating a time/frequency hopping signal.

7. The method of Claim 1 wherein said spectrally spreading a carrier comprises generating any FM signal where its modulation bandwidth is greater than said data pulse code waveform's bandwidth.

8. The method of Claim 1 wherein said spectrally spreading a carrier comprises generating an FM chirping signal.

9. The method of Claim 1 which further comprises modulating said data pulse code waveform with a second direct sequence pseudo-random pulse code waveform prior to modulating the spectrally spread carrier.

10. The method of Claim 1 wherein said modulating comprises pulse amplitude modulating and said MSS signal comprises a pulse amplitude modulated spectrally spread signal.

11. The method of Claim 10 which further comprises modulating a second direct sequence pseudo-random pulse code waveform with said MSS waveform.

12. The method of Claim 11 which further comprises:

transmitting said MSS signal,

receiving said MSS signal,

extracting said data pulse code waveform from said MSS signal.

13. The method of Claim 12 wherein said extracting comprises:

removing said spectrally spread carrier from said MSS signal resulting in a received pulse code waveform comprising:

said data pulse code waveform and

said second direct sequence pseudo-random pulse code waveform;

generating a third direct sequence pseudo-random pulse code waveform substantially similar to and in synchronization with said second direct sequence waveform;

gating said received pulse code waveform with said third direct sequence waveform;

filtering the output of said gating step resulting in an average value representing one of two possible logical values for said data pulse code waveform.

14. The method of Claim 13 wherein said generating a third direct sequence psuedo-random pulse code waveform (DSPPCW) comprises:

transmitting a preamble portion of said MSS signal wherein said data pulse code waveform is non-transitioning,

producing a clock waveform in-sync with said second DSPPCW,

performing a sequential correlation comparison between said received pulse code waveform and each of a plurality of candidate waveforms,

recording the results of each comparison,

chosing the candidate with a highest correlation value as said third DSPPCW.

15. The method of Claim 14 which comprises:

using said clock waveform as a return carrier frequency

source.

16. An apparatus for identifying and tracking the whereabouts of moving bodies around a defined area which comprises:

an interrogating station including a first transceiver;

said first transceiver comprising:

means for generating a carrier,

means for spectrally spreading said carrier,

means for generating a data pulse code waveform, and

means for modulating said carrier with said data waveform resulting in a modulated carrier waveform;

at least one tag associated with one of said bodies,

said tag including a second transceiver,

said second transceiver comprising:

means for extracting said data pulse code waveform from said modulated carrier waveform.

17. The apparatus in Claim 16 wherein said means for spectrally spreading said carrier comprises a means for phase shift keying (PSK) said carrier with a first direct sequence pseudo-random pulse code waveform.

18. The apparatus of Claim 16 wherein said means for phase shift keying comprises binary phase shift keying (BPSK).

19. The apparatus of Claim 16 wherein said means for spectrally spreading comprises a means for generating a frequency hopping

signal.

20. The apparatus of Claim 16 wherein said means for spectrally spreading comprises a means for generating a time hopping signal.

21. The apparatus of Claim 16 wherein said means for spectrally spreading comprises a means for generating a time/frequency hopping signal.

22. The apparatus of Claim 16 wherein said means for spectrally spreading comprises a means for generating any FM signal where its modulation bandwidth is greater than said data waveform's bandwidth.

23. The apparatus of Claim 16 wherein said means for spectrally spreading comprises a means for generating an FM chirping signal.

24. The apparatus of Claim 16 which further comprises means for modulating said data waveform with a second direct sequence pseudo-random pulse code waveform.

25. The apparatus of Claim 24 wherein said means for modulating said data waveform comprises a means for multiplying said data waveform with said second direct sequence waveform.

26. The apparatus of Claim 24 wherein said means for extracting comprises:

means for removing said spectrally spread carrier from said modulated carrier waveform resulting in a received pulse code waveform comprising:

said data pulse code waveform and

said second direct sequence pseudo-random pulse code waveform;

means for generating a third direct sequence pseudo-random pulse code waveform substantially similar to and in synchronization with said second direct sequence waveform;

means for gating said received pulse code waveform with said third direct sequence waveform;

means for filtering the output of said means for gating resulting in an average value representing one of two possible logical values for said data pulse code waveform.

27. The apparatus of Claim 26 wherein said means for generating a third direct sequence psuedo-random pulse code waveform (DSPPCW) comprises:

means for transmitting a preamble portion of said MSS signal wherein said data pulse code waveform is non-transitioning,

means for producing a clock waveform in-sync with said second DSPPCW,

means for performing a sequential correlation comparison between said received pulse code waveform and each of a plurality of candidate waveforms,

means for recording the results of each comparison,

means for chosing the candidate with a highest correlation

value as said third DSPPCW.

28. The apparatus of Claim 14 wherein said clock waveform provides the source of a return carrier frequency.

Abstract of the Disclosure

MODULATED SPREAD SPECTRUM IN RF IDENTIFICATION SYSTEMS

A method for RF communication between transceivers in a radio frequency identification system that improves range, decreases multipath errors and reduces the effect of outside RF source interference by employing spread spectrum techniques. By pulse amplitude modulating a spread spectrum carrier before transmission, the receiver can be designed for simple AM detection, suppressing the spread spectrum carrier and recovering the original data pulse code waveform. The data pulse code waveform has been further encrypted by a direct sequence pseudo-random pulse code. This additional conditioning prevents the original carrier frequency components from appearing in the broadcast power spectra and provides the basis for the clock and transmit carrier of the transceiver aboard an RFID tag. Other advantages include high resolution ranging, hiding transmissions from eavesdroppers, and selective addressing.

JDB>1590p9.app

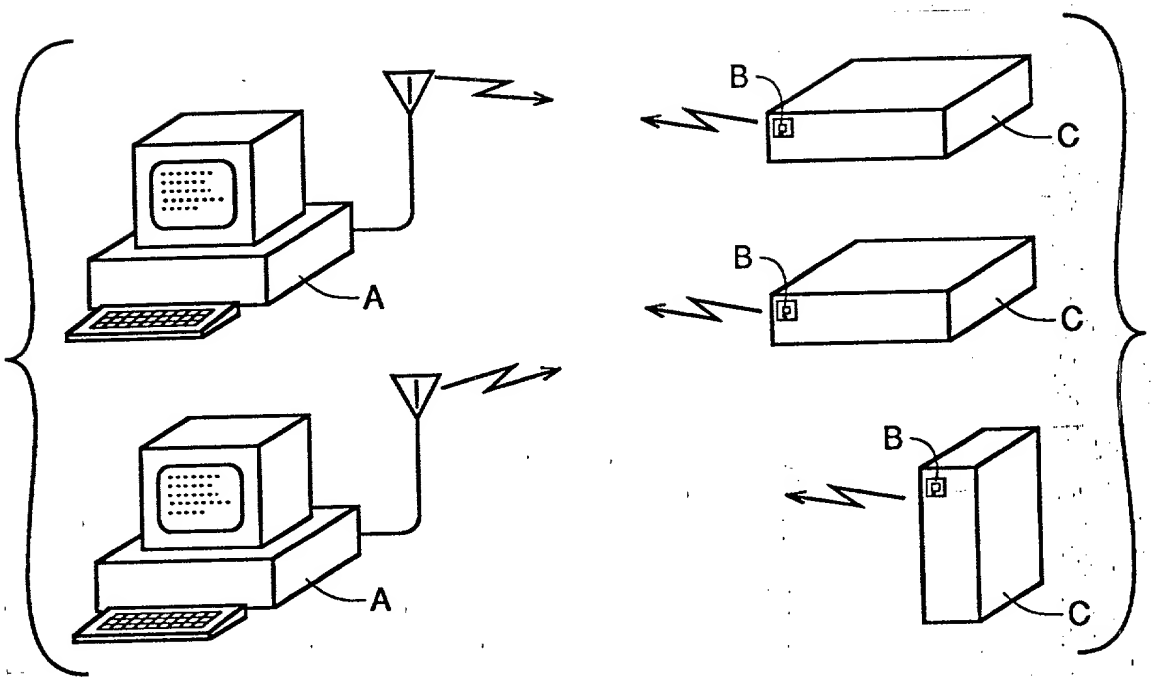


FIG. 1

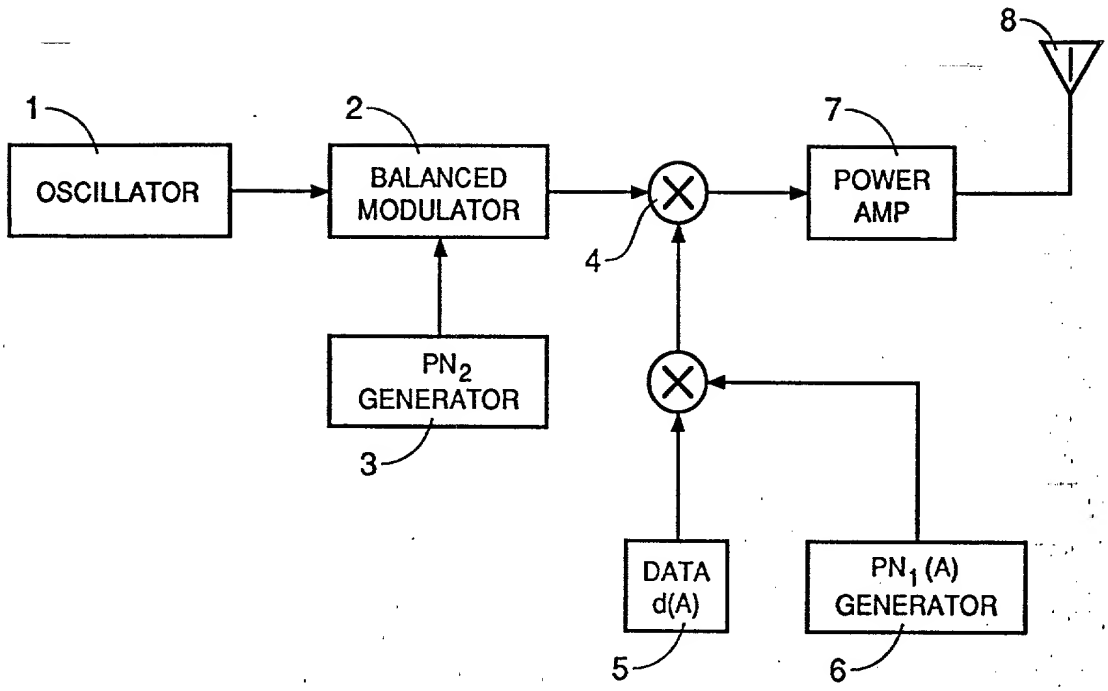

1
OSCILLATOR
2
BALANCED MODULATOR
3
PN2 GENERATOR
4
7
POWER AMP
8
5
DATA d(A)
6
PN1 (A) GENERATOR

FIG. 2

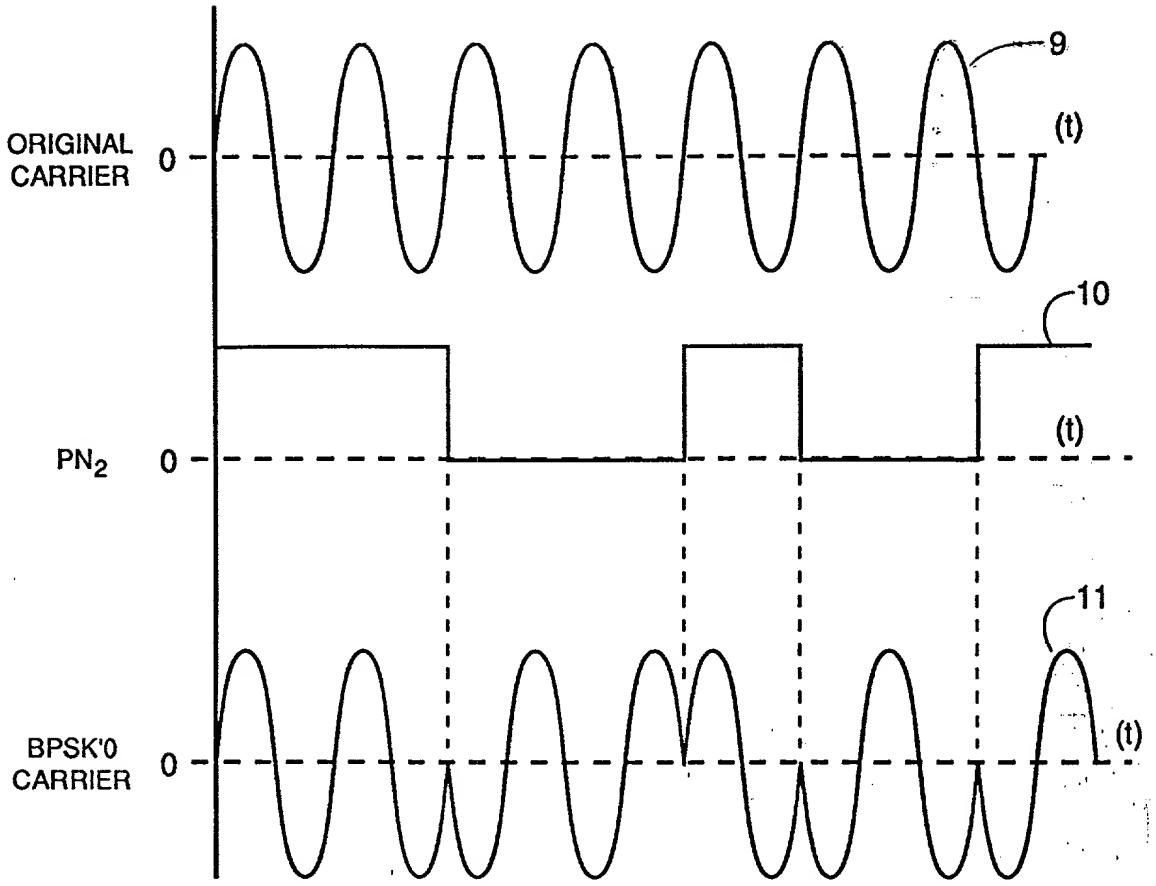

ORIGINAL CARRIER
0
9
(t)
PN2
0
10
(t)
BPSK'0 CARRIER
0
11
(t)

FIG. 3

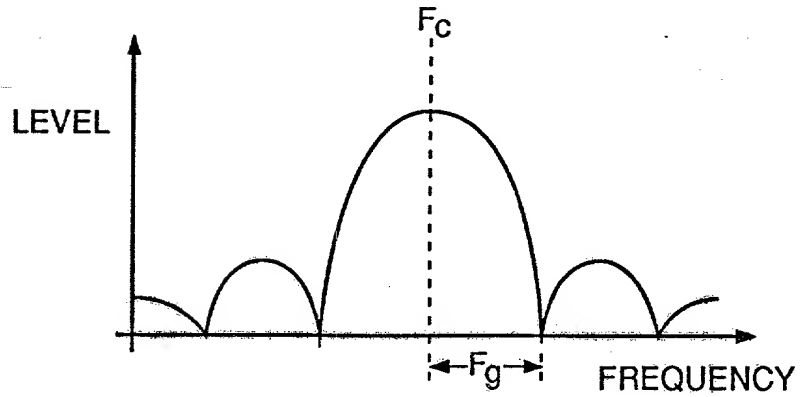
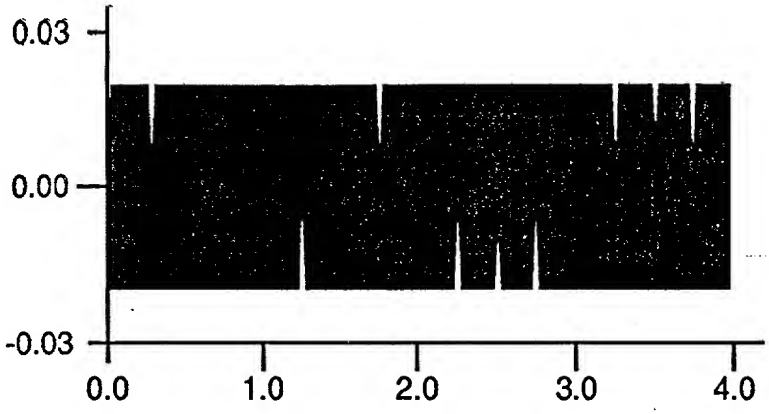

Fc
LEVEL
Fg
FREQUENCY

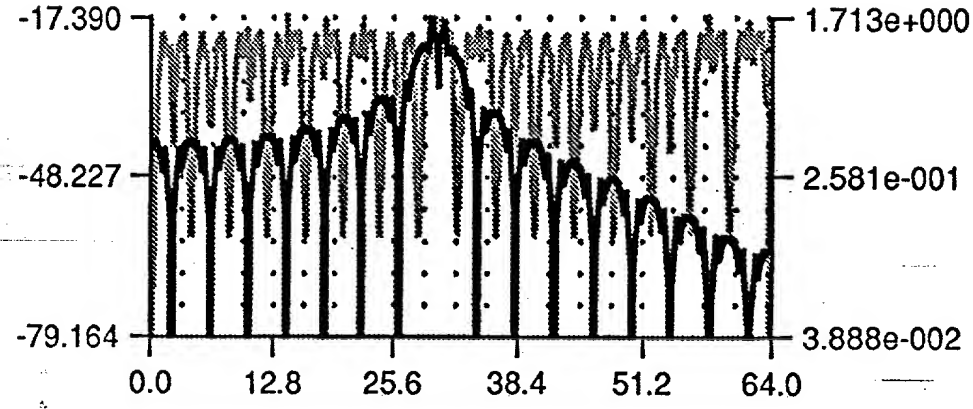
FIG. 4



BIPHASE CARRIER MODULATION

$$\cos\left[\omega_0 t + \pi/2 PN_2(t)\right]$$

FIG. 5A



BIPHASE CARRIER MODULATION SPECTRUM

FIG. 5B

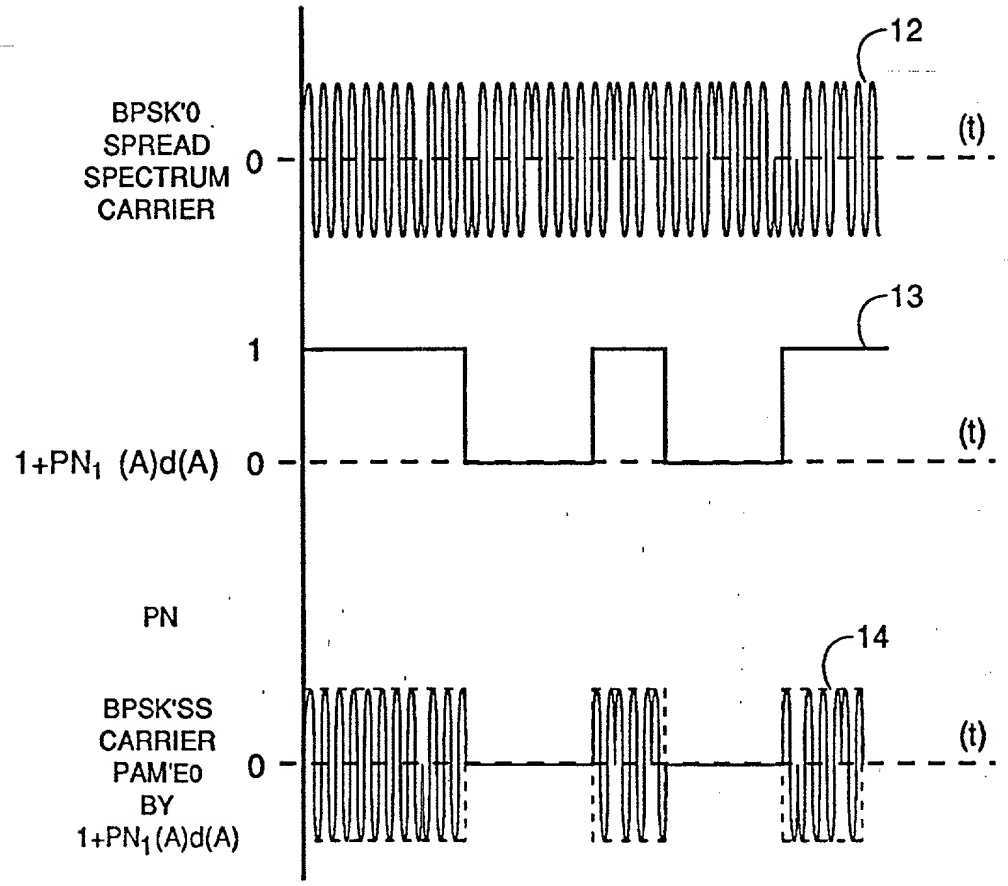
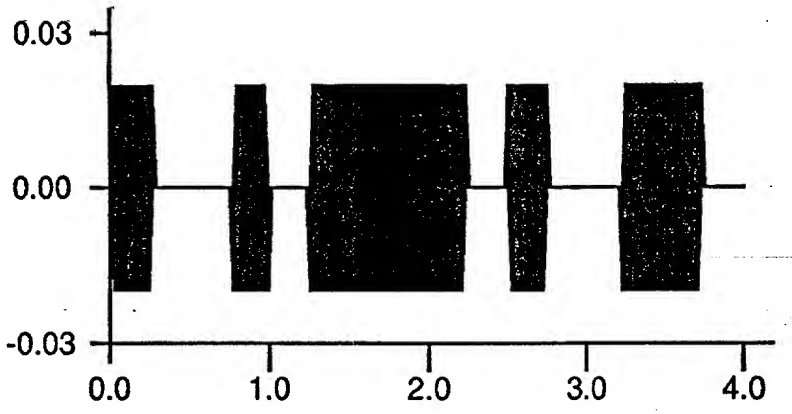

12
BPSK'0
SPREAD
SPECTRUM
CARRIER
0
(t)
13
1
1+PN1 (A)d(A)
0
(t)
PN
14
BPSK'SS
CARRIER
PAM'E0
BY
1+PN1(A)d(A)
0
(t)

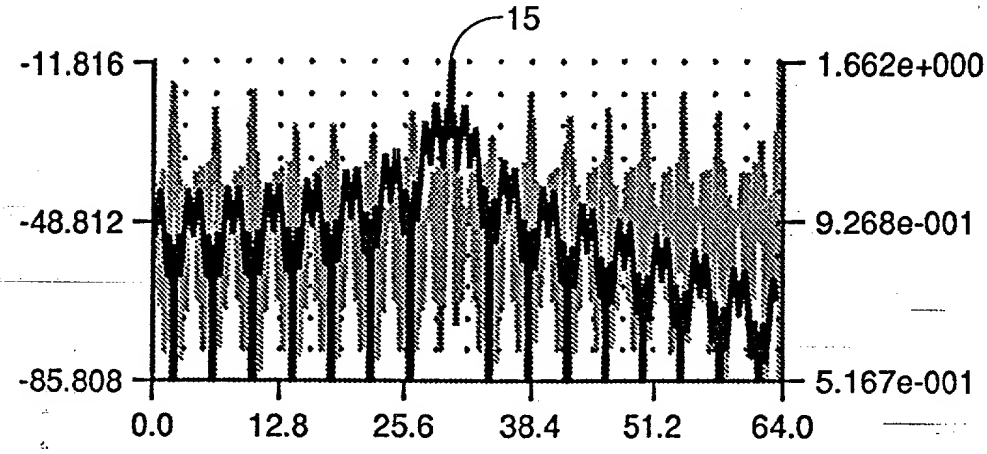
FIG. 6



AMPLITUDE ON-OFF CARRIER MODULATION

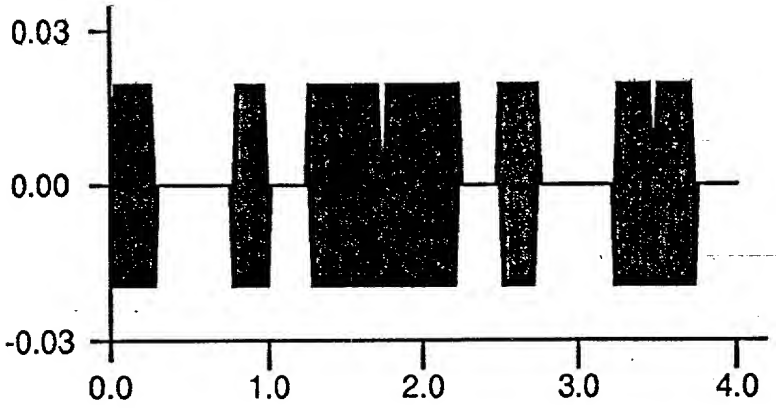
$$[1+PN_1(t)]\cos[\omega_0 t]$$

FIG. 7A



AMPLITUDE ON-OFF CARRIER MODULATION SPECTRUM

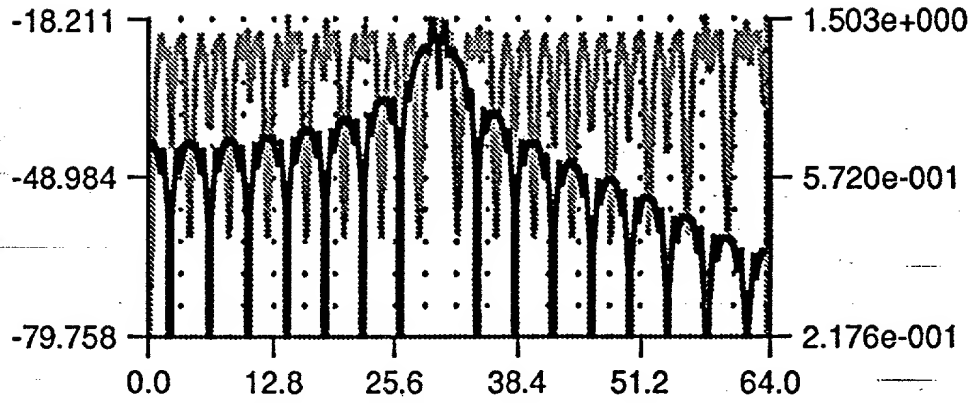
FIG. 7B



AMPLITUDE ON-OFF PLUS
BIPHASE CARRIER MODULATION

$$[1+PN_1(t)]\cos[\omega_0 t+\pi/2 PN_2(t)]$$

FIG. 8A



AMPLITUDE ON-OFF PLUS BIPHASE
CARRIER MODULATION SPECTRUM

FIG. 8B

Z6ET2D'BT600880

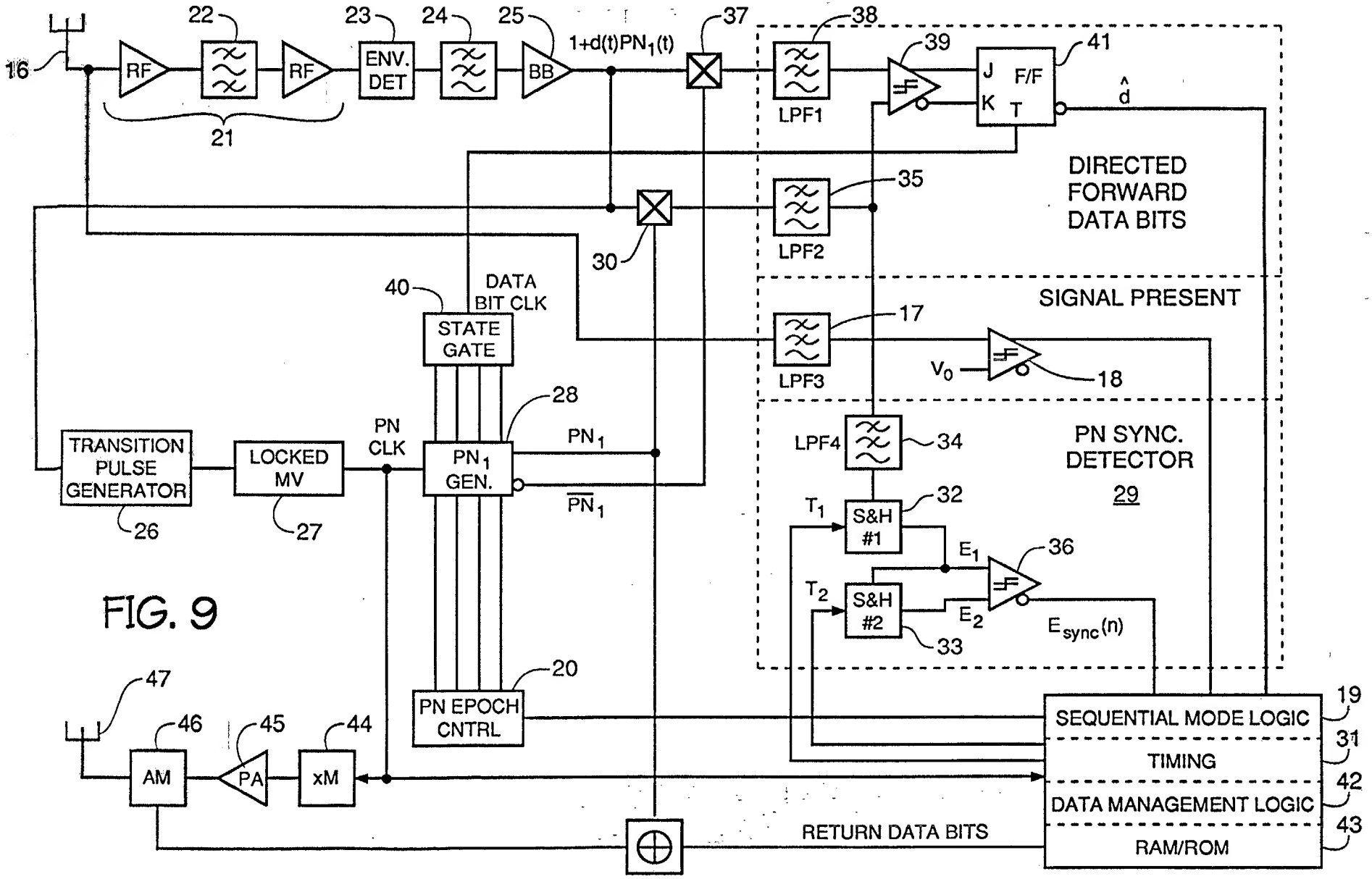


FIG. 9

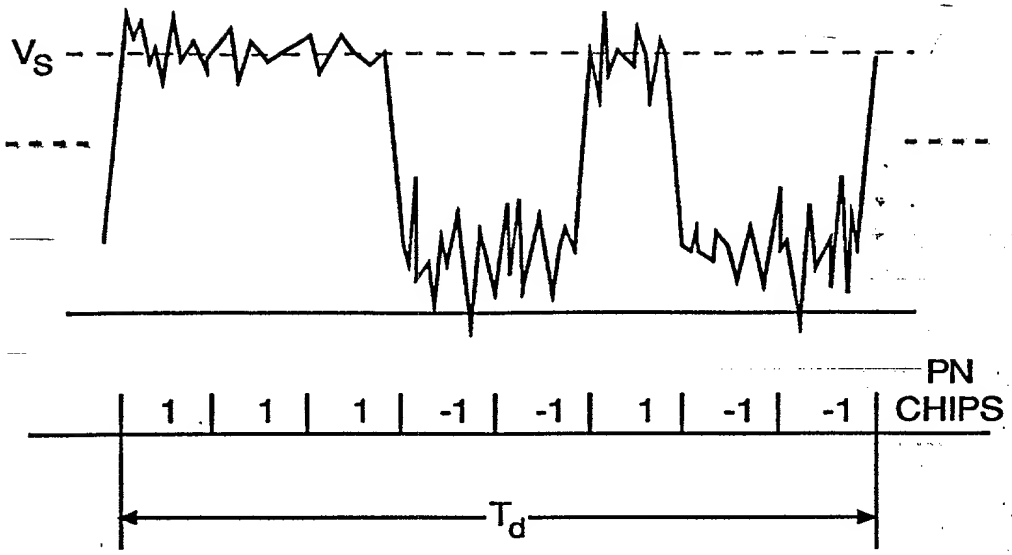


FIG. 10

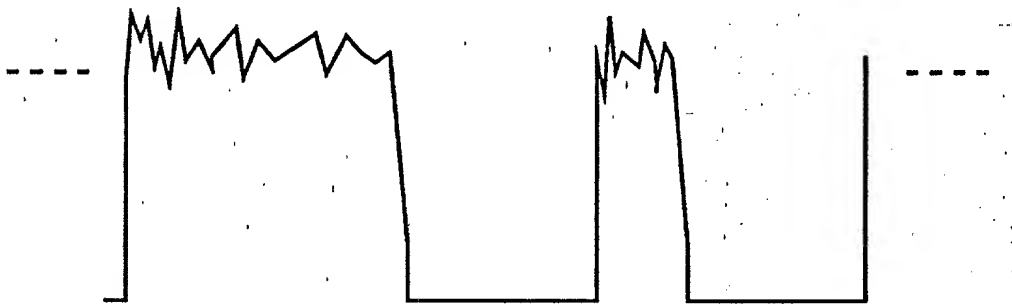


FIG. 11

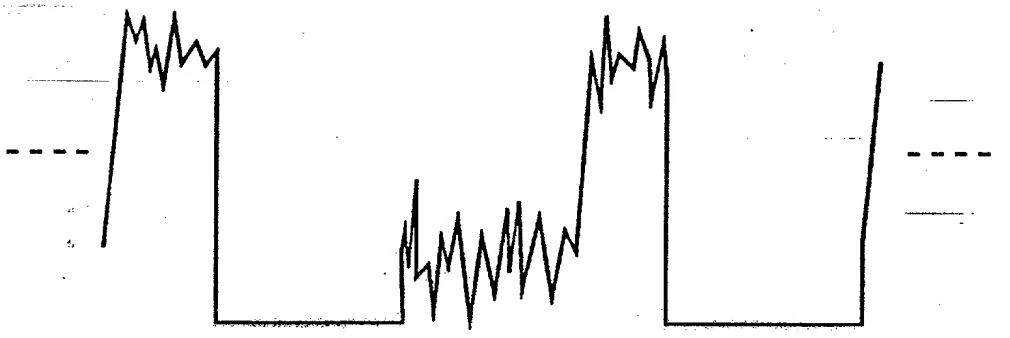


FIG. 12

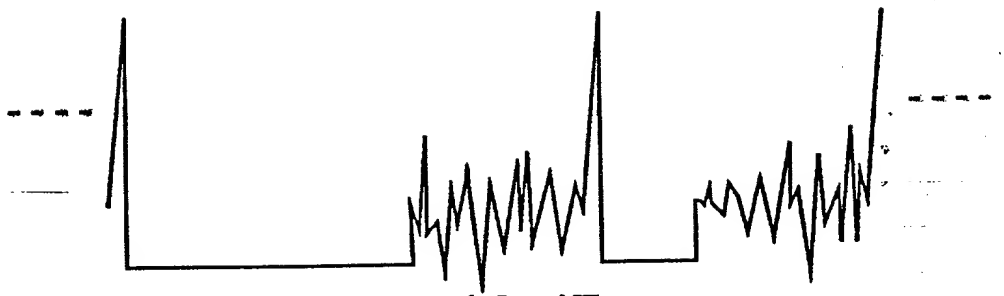


FIG. 13

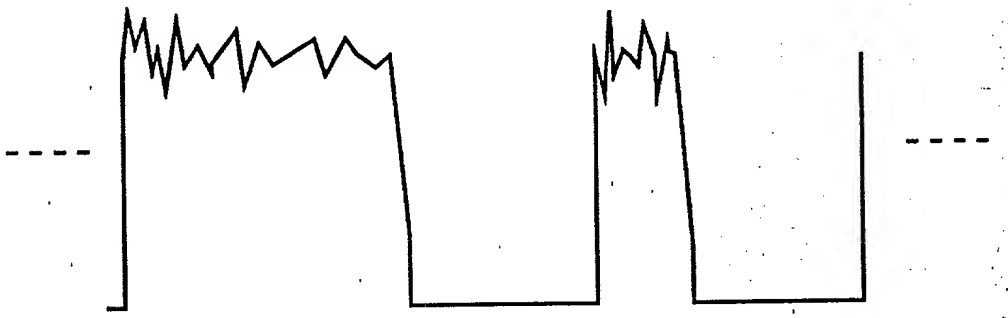


FIG. 14

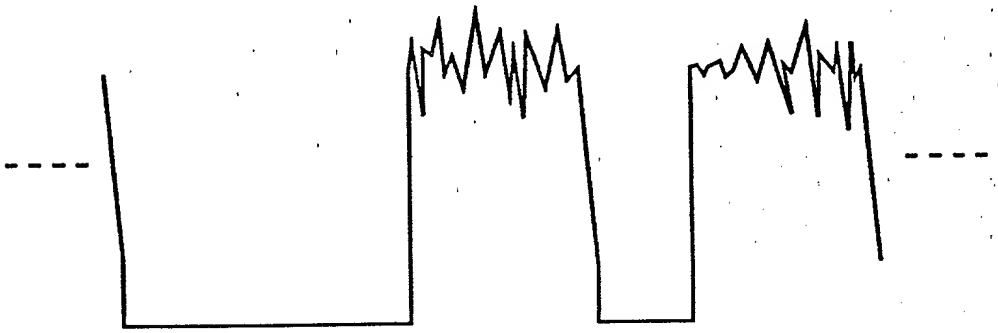


FIG. 15

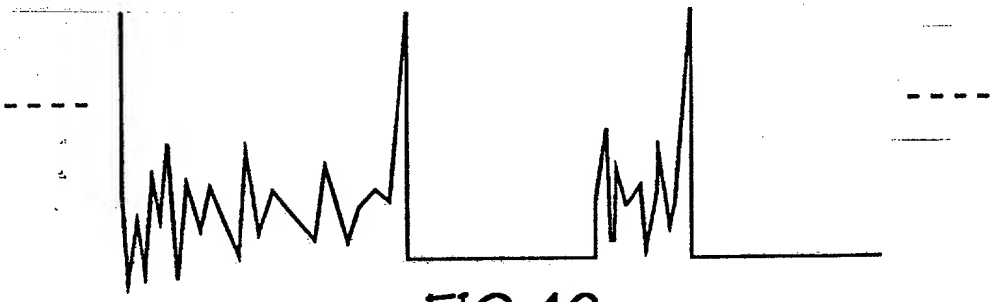


FIG. 16

DECLARATION AND POWER OF ATTORNEY
Original Application

Attorney's Docket No. 1590.1-9R

MAIL ROOM FEB 13 1997 99 PAT. & TRADEMARK OFFICE

As the below-named inventor, I declare that the information given herein is true, that I believe that I am the original, first and sole inventor if only one name is listed at 201 below, or a joint inventor if plural inventors are named at 201-204 below, of the subject matter for which patent is sought on the invention entitled:

MODULATED SPREAD SPECTRUM IN RF IDENTIFICATION SYSTEMS METHOD

which is described and claimed in: [ ] the attached specification or [X] the specification in application Serial No. 08/348,274 filed November 30, 1994, and amended on N.A.

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37 CFR 1.56(a).

For Prior Foreign Applications Only:
I hereby claim foreign priority benefits under Title 35 USC 119 of any foreign application for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed: ~~Priority Claimed~~

(number)	(Country)	(day/Mo,/Yr.filed)	(Yes)	(No)
N.A.				

For Prior U.S. Applications Only:
I hereby claim the benefit under Title 35 USC 120 of any United States application(s) listed below and insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35 USC 112, I acknowledge the duty to disclose material information as defined in Title 37 CFR 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(Appln. S/N)	(Filing Date)	(Status, i.e. patented, pending, abandoned
N.A.		

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith.

HENRI J.A. CHARMASSON, Registration No. 27,478
JOHN D. BUCHACA, Registration No. 37,289

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1545 Hotel Circle So., Suite 150
San Diego, CA 92108

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Henri J. A. Charmasson or
John D. Buchaca
(619) 294-2922 FAX: (619) 294-8674

PATS>PATDEC.POA

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

201	FULL NAME OF INVENTOR	FAMILY NAME: TUTTLE	FIRST GIVEN NAME: JOHN	SECOND GIVEN NAME: R.
	RESIDENCE & CITIZENSHIP	CITY: CORRALES	STATE OR FOREIGN COUNTRY: NEW MEXICO	COUNTRY OF CITIZENSHIP: USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: 1516 MEADOW LARK LANE	CITY: CORRALES	STATE & ZIP CODE/COUNTRY: NEW MEXICO 87048
202	FULL NAME OF INVENTOR	FAMILY NAME: HOYT	FIRST GIVEN NAME: EUGENE	SECOND GIVEN NAME: P.
	RESIDENCE & CITIZENSHIP	CITY: COLORADO SPRINGS	STATE OR FOREIGN COUNTRY: COLORADO	COUNTRY OF CITIZENSHIP: USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: 18 RISING SUN TERRACE	CITY: COLORADO SPRINGS	STATE & ZIP CODE/COUNTRY: COLORADO 80921
203	FULL NAME OF INVENTOR	FAMILY NAME: SPRINGETT	FIRST GIVEN NAME: JAMES	SECOND GIVEN NAME: C.
	RESIDENCE & CITIZENSHIP	CITY: LA CRESCENTA	STATE OR FOREIGN COUNTRY: CALIFORNIA	COUNTRY OF CITIZENSHIP: USA
	POST OFFICE ADDRESS	POST OFFICE ADDRESS: 2670 ORANGE AVENUE	CITY: LA CRESCENTA	STATE & ZIP CODE/COUNTRY: CALIFORNIA 91214

SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE JOHN R. TUTTLE 2-10-95	DATE EUGENE P. HOYT	DATE JAMES C. SPRINGETT

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Original Application

Attorney's Docket No. 1590.1-9R

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N.A.				
(number)	(Country)	(day/Mo,/Yr.filed)	(Yes)	(No)
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(Appln. S/N)	(Filing Date)	(Status,i.e. patented, pending, abandoned
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JC PTO 08/348274

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	RESIDENCE & CITIZENSHIP	CITY CORRALES	STATE OR FOREIGN COUNTRY NEW MEXICO	COUNTRY OF CITIZENSHIP USA
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	RESIDENCE & CITIZENSHIP	CITY LA CRESCENTA	STATE OR FOREIGN COUNTRY CALIFORNIA	COUNTRY OF CITIZENSHIP USA
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SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
	Eugene P. Hoyt	
DATE JOHN R. TUTTLE	DATE EUGENE P. HOYT 2/4/95	DATE JAMES C. SPRINGETT

PTO/SB/01 (08-94)
Approved for use through 08/31/95. OMB 0651-0032
Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

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Original Application

Attorney's Docket No. 1590.1-9R

FEB 1 1995 PAT. & TRADEMARK OFFICE

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SIGNATURE OF INVENTOR 201	SIGNATURE OF INVENTOR 202	SIGNATURE OF INVENTOR 203
DATE JOHN R. TUTTLE	DATE EUGENE P. HOYT	DATE JAMES C. SPRINGETT 6 Feb. 1995